TEXAS INSTRUMENTS
TMS320 DIGITAL SIGNAL PROCESSOR
PRODUCT FAMILY BULLETIN

OVERVIEW

Digital signal processors offer a high-performance, cost-effective and easy-to-use solution in many traditional as well as non-traditional and emerging signal processing applications.

Digital signal processing involves the representation, transmission and manipulation of signals using numerical techniques and digital processors. Single-chip digital signal processors (DSPs) are high-speed microprocessors optimized for number-crunching.

DSPs are moving into the mainstream, enjoying success and proliferation similar to that of general-purpose microprocessors. These cost-effective devices provide high performance, programmability and reliability in applications which had used performance-limited microprocessor, expensive custom or environment-sensitive analog solutions, including:

- Active suspension in automobiles
- 3-D graphics
- Cellular phones
- High-speed servo control
- Image processing
- Multimedia
- Fax modems

Texas Instruments, the recognized leader in general-purpose, single-chip DSPs, offers a wide range of fixed- and floating-point DSP solutions. Currently over 10,000 users enjoy the benefits that TI TMS320 DSPs bring to applications. High-performance single- and multi-DSP solutions offer 40-megaflop performance and beyond. Low-cost single-chip devices, available for as little as $3, make DSP viable for even the most cost-sensitive applications like consumer and automotive products.

And, since ease-of-use and time-to-market are a primary concern, TI offers world-class development tools and support. TI's DSP development support equals that offered for general-purpose microprocessors, effectively shortening the development cycle and helping to speed products to market.

TMS320 Digital Signal Processors have found success in a wide variety of applications.

FEATURES	BENEFITS
❑ Device throughput to 40 MFLOPS ❑ Device cycle times as fast as 35 ns	❑ High performance
❑ High level of system integration ❑ Low-cost solutions, as low as $.80 per MIP	❑ Lower system cost
❑ World-class support and development environment	❑ Ease of use ❑ Shorter development times
❑ Programmability ❑ Device compatibility	❑ Flexibility/upgradeability
❑ Digital solution	❑ Reliability; manufacturability

THE ADVANTAGES OF DIGITAL SIGNAL PROCESSORS

DIGITAL SIGNAL PROCESSING

Digital signal processing involves the processing and manipulation of digital signals in real time. An analog signal such as speech is filtered, sampled using an analog to digital converter (A/D) and then input to a device such as a digital signal processor (DSP). The DSP performs a series of math-intensive functions manipulating the digital signal. A digital to analog converter returns the signal to the analog domain form, with the desired result.

DIGITAL SIGNAL PROCESSORS

Single-chip, general-purpose digital signal processors offer numerous advantages over other signal processing solutions like analog circuits, general-purpose microprocessors and bit-slice or custom components. DSPs are microprocessors optimized for high-speed number-crunching or multiply/accumulate (MAC) math-intensive applications.

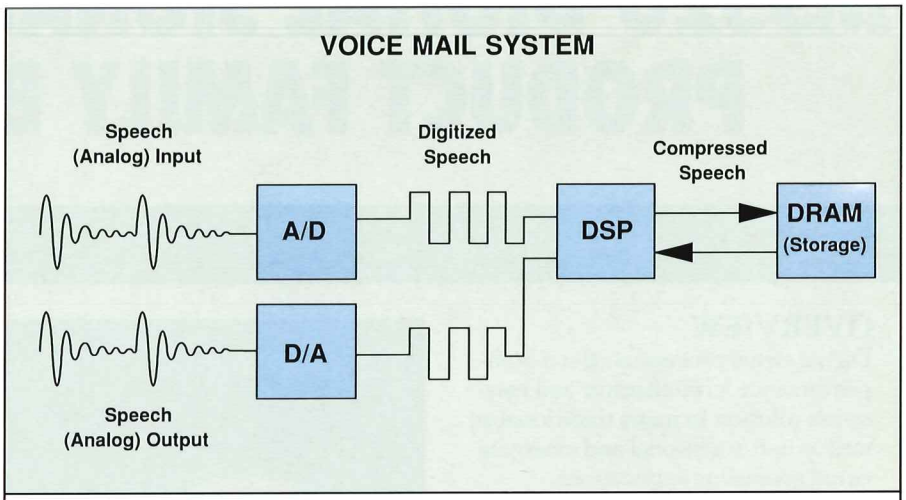
Benefits of DSPs include greater reliability, higher performance and throughput, cost-effectiveness and ease-of-use. In addition, with a DSP solution, the hardware is straightforward, and the algorithm or software differentiates a system. This can mean that additional system features may be added for little or no additional cost.

A digital approach is not subject to environmental effects like component drift and aging, as is an analog approach. More and more applications are moving to digital solutions like DSPs because they are inherently more reliable and offer repeatable results. Another advantage over an analog solution is the ability to simulate a DSP design in software for easy modification. This can substantially reduce development time. Even very complex functions in analog can be straightforward using digital techniques.

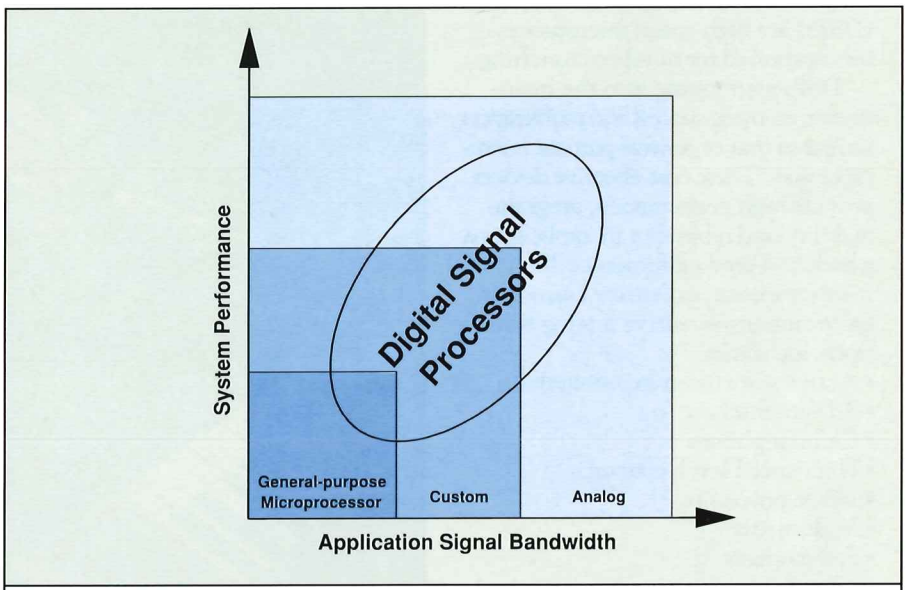
Digital signal processors provide a higher level of sustained, real-time performance and throughput than a general-purpose microprocessor, offering as much as ten times the performance/throughput in numerically-intensive tasks. The same development environment traditionally enjoyed in microprocessor development is available for TI's TMS320 DSPs. This enhances ease-of-use and can shorten development time for faster time-to-market. In addition, TI DSP devices are available at prices comparable to prices for general-purpose microprocessors and microcontrollers.

DSPs are experiencing a proliferation similar to that of the general-purpose microprocessor in the 1970's, as advances in single-chip DSP technology enable new applications for DSP in graphics, imaging, neural networking and high-speed embedded applications.

DSPs are programmable, offering several advantages over bit-slice and custom solutions. Programmability means that designs are flexible and can be easily upgraded. DSPs are available "off-the-shelf" for less risk and shorter development times. DSPs are less expensive in the majority of applications where volume does not warrant the expense of a custom solution. Comprehensive development support and a large existing software base make DSP development much easier than the custom approach.



This voice mail system is representative of a typical DSP system. Speech is input, digitized, compressed and stored until accessed.



DSPs offer numerous advantages over other signal processing solutions, throughout a similar application-performance range.

SERVING A GROWING SPECTRUM OF APPLICATIONS

TRENDS IN DSP APPLICATIONS

TMS320 digital signal processors have found success in a wide variety of applications due to their performance, reliability, programmability and cost-effectiveness.

Widespread use of TMS320 DSPs first began in what are now considered "traditional" applications for DSP, such as telecommunications and data communications. DSP device technology continues to advance, resulting in even higher performance and lower cost. This means that new applications are enabled as DSP solutions become technically feasible and/or cost-effective. "Non-traditional" or emerging DSP applications include high-speed servo control, graphics/image processing and multimedia.

TRADITIONAL DSP APPLICATIONS

In traditional applications for digital signal processors (such as telecom, datacom and audio processing), DSPs commonly perform speech and audio processing, fast Fourier transforms (FFTs) and spectral analysis. Such voice, speech and audio functions use arrays of data and can benefit from DSP-specific features such as fast multiply, add and data move capabilities. The TMS320 DSP family architecture is designed to maximize performance in these types of functions.

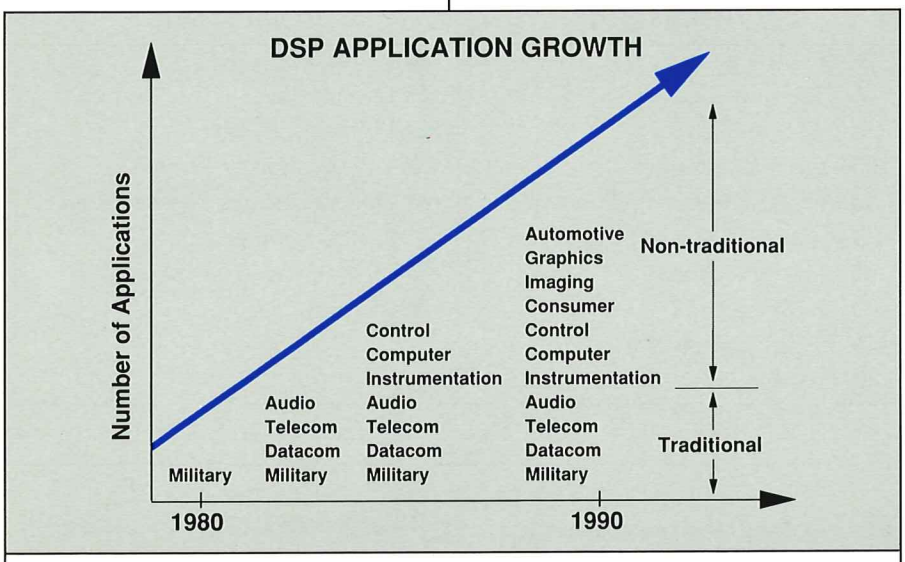
Applications in telecommunications include echo cancellation, multiplexing, transcoding and rate adapters. Consumer telecom-type applications include answering machines and cellular telephones.

Data communications applications include fax and data modems. Audio processing applications include high-fidelity sound systems for music synthesis, graphics equalization and surround-sound effects.

Traditional DSP applications are also expanding into cost-sensitive areas as the price of DSPs comes down. For example, cellular telephony is currently moving from traditional analog solutions to an all-digital DSP solution, which can provide greater call-carrying capacity in the same bandwidth. Answering machines are also moving to all-digital solid-state DSP solutions for increased functionality and reliability.

"NON-TRADITIONAL" AND EMERGING DSP APPLICATIONS

The growth in the DSP market continues to be fueled by the move to DSP in non-traditional and emerging applications, as increases in DSP performance, throughput and integration and the addition of more general-purpose features make DSP technically feasible and/or cost-effective.



The growth in the number of DSP applications is fueled by the proliferation of DSPs in non-traditional applications.

DSPs manipulate control signals in high-speed servo control applications such as hard disk drives, auto engine control, braking and suspension and in robotics and industrial motor control. Use of DSP to implement control algorithms increases precision and performance by eliminating the need for look-up tables which can require additional memory and slow system response time. TMS320 DSP devices are available which are optimized for control applications, incorporating many control peripheral functions on chip. This increases system performance and reduces board space and cost.

In embedded applications DSP can often handle not only the embedded task but also I/O-intensive system management functions typically handled by a host CPU. This is due to potential performance "surplus" and general-purpose features of a DSP. Such applications include multimedia, graphics and imaging—anywhere a RISC is used.

DSPs are used as high-speed math coprocessors for matrix operations in 3-D graphics and imaging. TI TMS320 DSPs bring essential programmability, high system integration, easy host interface, multiprocessing capability and high sustained throughput to these computation-intensive tasks. The DSP may function as the transform engine in high-performance 3-D graphics, as the DCT/convolution processor in imaging systems and the connection processor in neural networks.

Many consumer applications take advantage of low-cost TMS320 DSPs. DSP can bring new capabilities to consumer applications in speech, audio, radar detection, power tools and toys and games.

Not all applications fall into a specific category, however. Multimedia is a good example of a combination of traditional and non-traditional applications. Multimedia can combine applications in telephony, speech recognition, graphics/imaging and audio processing.

Many commercial applications such as telecom, datacom, control and imaging are also military applications. TI SMJ320 DSPs meet the needs of military applications with higher reliability and stringent testing standards. An Ada compiler is available to support DSP design in military applications.

TMS320 DSPs: IDEAL FOR A VARIETY OF APPLICATIONS

Applications for digital signal processors continue to proliferate. As DSPs move further into the mainstream, the possible applications are limited only by the designer's imagination.

Telecommunications—In telecommunications applications, DSPs provide inherent system flexibility, increase channel capacity and lower system cost by eliminating the need for independent dedicated microprocessors.

Control—DSP control algorithms eliminate the need for look-up tables which require additional memory and slow the system response time and bandwidth. Other DSP benefits ideal for this application include on-chip peripherals and a high-performance CPU for real-time processing and higher precision.

Automotive—DSPs support closed loop control for optimal powertrain management and body and chassis control. Their use also provides improved reliability, safety and vehicle stability; reduced engine noise and vibration; and better anti-theft security.

Military—Many commercial DSP applications, such as telecommunications, data communications, control and image processing, are also military applications, using military DSPs produced to more stringent testing and reliability standards.

Consumer—Low-cost, programmable DSPs are available for cost-sensitive consumer applications. They bring new capabilities to these products, including speech I/O, digital recording and sophisticated control functions. Comprehensive DSP development support shortens time-to-market, also.

Multimedia—Multimedia applications require DSPs to perform multitasking in an I/O-intensive environment. DSPs are ideally suited for this application due to their multitasking capability and software availability.

Computer/graphics/imaging—DSPs bring essential programmability, easy host interface, multiprocessing capability and high throughput to computation-intensive tasks requiring large volumes of memory and data I/O. DSP support tools ease design and speed time-to-market.

Data communications—DSPs are ideal in data communications applications, performing multiple communication algorithms with system controller capabilities. DSPs add channel capacity and system flexibility, thus lowering overall system cost.

APPLICATIONS FOR DSP

TELECOMMUNICATIONS

- Cellular Telephones
- Cordless Phones
- 1200 to 19200 bps Modems
- FAX
- Personal Communicators
- Transcoders
- Echo Cancellation
- Digital PBXs
- Spread Spectrum Communications
- Channel Multiplexing
- Adaptive Equalizers
- DTMF Encoding/Decoding
- Data Encryption
- Speaker Phones
- Digital Speech Interpolation
- X.25 Packet Switching
- Video Conferencing
- Line Repeaters
- ISDN

CONSUMER

- Solid State Answering Machines
- Music Synthesizer
- Radar Detectors
- Power Tools
- Digital Audio/TV
- Educational Toys

INDUSTRIAL

- Robotics
- Numeric Control
- Security Access
- Power Line Monitors
- Motor Control

INSTRUMENTATION

- Spectrum Analysis
- Function Generation
- Pattern Matching
- Seismic Processing
- Transient Analysis
- Digital Filtering
- Phase-Locked Loops

MILITARY

- Secure Communications
- Radar Processing
- Sonar Processing
- Image Processing
- Navigation
- Missile Guidance
- Radio Frequency Modems

AUTOMOTIVE

- Engine Control
- Vibration Analysis
- Noise Cancellation
- Electronic Mufflers
- Antiskid Brakes
- Adaptive Ride Control
- Global Positioning
- Navigation
- Voice Commands
- Digital Radio

COMPUTER

- 3-D Graphics
- Multimedia
- Hard Disk Drives
- Laser Printers
- Optical Character Recognition
- Neural Networks
- High-Speed Array Processors
- Imaging

EXTENSIVE TMS320 SUPPORT SHORTENS DESIGN TIME

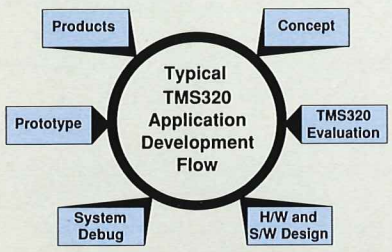
Fast time to market, design ease and increased productivity are key in DSP system design. In addition, DSP applications are typically more algorithm-intensive; thus, development tools and support play an important role in the success of a project. TI sets the industry support standard with a world-class offering of leading-edge development tools and technical support. TI offers the same development environment for DSP that has been enjoyed in general-purpose microprocessor design, allowing users to easily take advantage of the benefits of DSP.

DSP SUPPORT

TI offers the industry's most comprehensive support program of software and hardware tools and technical assistance. Leading-edge tools include: optimizing high-level language compilers (C and Ada), C/assembly source debuggers, low-cost evaluation tools, simulators, assembler/linkers, scan-based emulators and the first DSP operating system, SPOX. Technical assistance is available through the TI field technical staff and Regional Technology Centers (RTCs). TI DSP personnel are available to answer technical questions through the TMS320 hotline, and the TMS320 bulletin board service may be accessed for product information and application code.

In addition, over 2,000 pages of applications notes and code and an extensive library of DSP texbooks are available. Over 200 universities take advantage of the TMS320 University Program. Hands-on workshops are offered through TI, and more than 100 third parties and consultants offer TMS320 development products and services.

TMS320 DEVELOPMENT SUPPORT



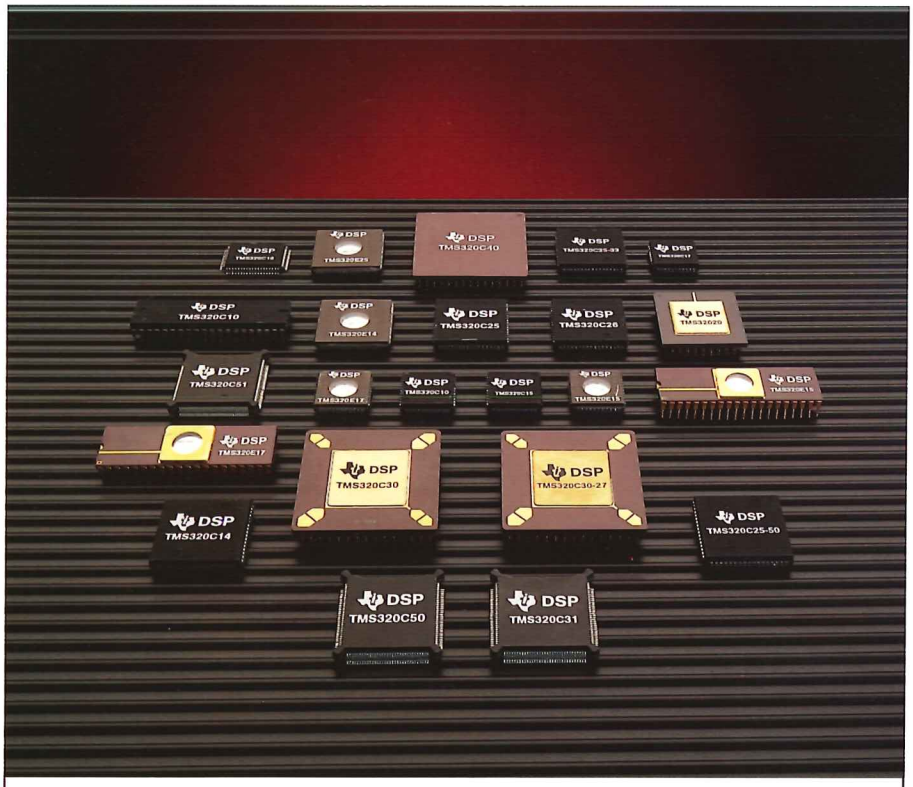
TI's offering of world-class development support assists designers in all aspects of TMS320 system design.

TI DSP SUPPORT TOOLS

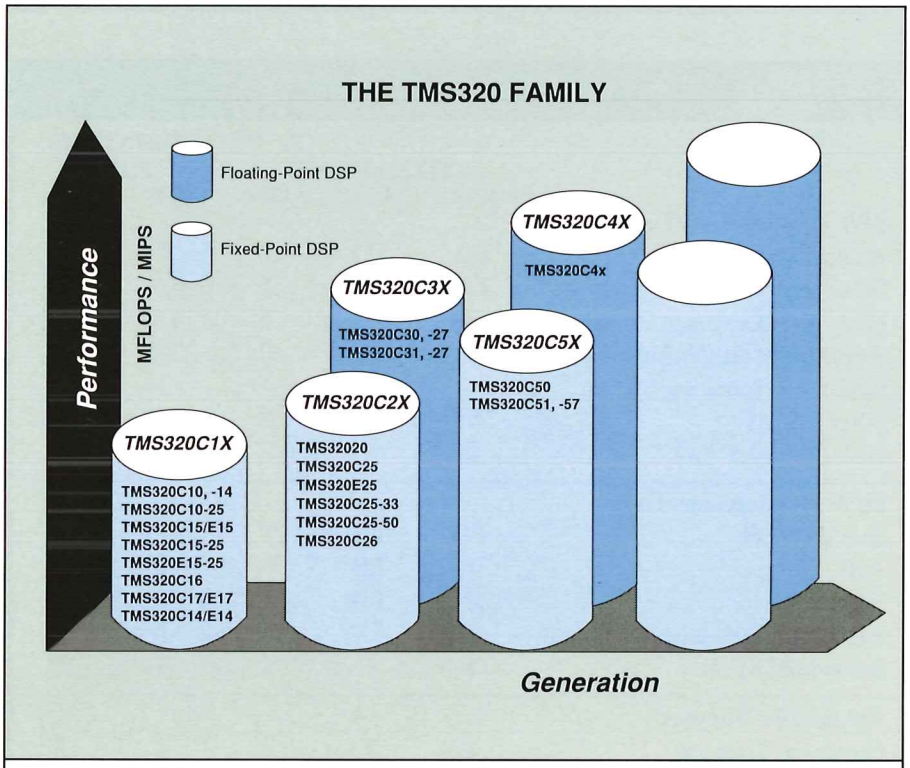
	FIXED-POINT			FLOATING-POINT	
	C1x	C2x	C5x	C3x	C4x
S/W Development Tools					
Assembler/Linker	T/3	T/3	T	T	P
Simulator	T/3	T/3	T	T/3	P
High-level Language Compiler	3	T/3	T	T/3	P
Application Algorithms	T/3	T/3	P	T/3	P
Real-time Operating System	—	—	—	3	P
Filter Design	T/3	T/3	P	T/3	P
HLL Debugger	P	P	T	T	P
H/W Development Tools					
EVM/SWDS	T/3	T/3	T	T/3	P
AIB	T/3	T/3	P	3	P
Emulator	T/3	T/3	T	T	P
Algorithm Development Board	T	T	T	T	T
Behavioral Models	3	3	P	3	P
Application Support					
Hands-on Training	T	T	P	T	P
Application Reports/Textbooks	T	T	P	T	P

T - Currently available from TI 3 - Available from a TI third party P - Planned; contact TI for availability

TI TMS320: THE DSP OF CHOICE



TI offers a broad family of compatible DSP devices.



Five generations of compatible DSPs offer fixed- and floating-point solutions from $3 to more than 40 MFLOPS.

Selecting the right DSP for your application involves the careful evaluation of several factors: performance, support, cost-effectiveness and compatibility. A DSP user must select the right DSP for his application, closely matching a device or devices to his particular performance and cost goals.

COMPLETE DSP SOLUTION

Only Texas Instruments offers a complete DSP solution with DSPs that set industry performance standards, world-class development support and a broad family of more than 20 compatible high-performance and low-cost DSPs. Since the introduction of the first TMS320 in 1982, TI DSPs have gained wide acceptance and won market leadership as the ideal solution to a broad range of DSP applications. Currently over 10,000 users take advantage of TI's complete DSP solution.

The TMS320 family consistently sets industry performance standards. TI fixed-point DSPs are capable of up to 30 MIPS. Floating-point DSPs perform up to 40 MFLOPS. Multiprocessing DSP solutions are capable of virtually unlimited system performance.

Meeting system cost goals is essential in DSP design. Over 20 TMS320 DSPs cover a wide range of price/performance alternatives. System cost is reduced as many DSP functions are integrated onto a single device. Volume production and advances in silicon processing allow reductions in the cost of DSPs, enabling new applications for DSP. Low-cost fixed-point solutions are available for cost-sensitive applications. Low-cost floating-point DSPs offer cost-effective floating-point performance.

EPROM and one-time programmable (OTP) DSPs support real-time code development and modification for instant evaluation of system performance. Form-factor emulation for system test reduces risk and supports early field test and production.

TMS320 FAMILY

Based on an advanced Harvard architecture, TMS320 DSPs are designed to execute an instruction in a single cycle. Performance is further optimized through a high degree of

$3 TO MORE THAN 40 MFLOPS ... THE DSP TO MEET YOUR NEEDS

TMS320 FAMILY MATRIX

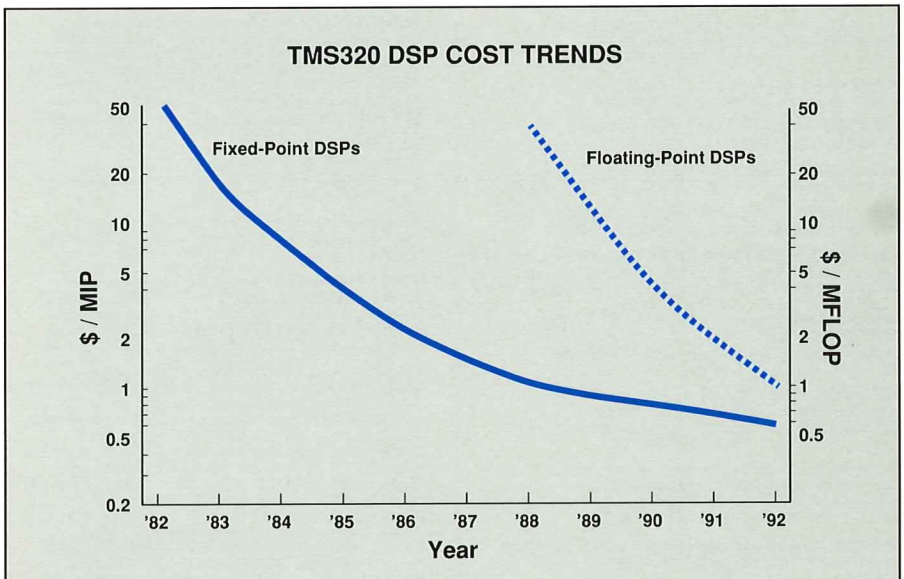
Data Type	Device	Cycle Time (ns)	Memory				I/O			On-Chip Timers	Package
			On-Chip			Off-Chip	Parallel	Serial	DMA		
			RAM	ROM	EPROM						
Fixed-Point	* TMS320C10	200	144	1.5K		4K	8×16				DIP/PLCC
	TMS320C10-25	160	144	1.5K		4K	8×16				DIP/PLCC
	TMS320C10-14	280	144	1.5K		4K	8×16				DIP/PLCC
	TMS320C14	160	256	4K		4K	7×16	1		4	PLCC
	TMS320E14	160	256		4K	4K	7×16	1		4	CERQUAD/PLCC
	* TMS320C15	200	256	4K		4K	8×16				DIP/PLCC
	* TMS320C15-25	160	256	4K		4K	8×16				DIP/PLCC
	* TMS320E15	200	256		4K	4K	8×16				DIP/CERQUAD/PLCC
	TMS320E15-25	160	256		4K	4K	8×16				DIP/CERQUAD
	TMS320C17	200	256	4K		4K	6×16	2		1	DIP/PLCC
	TMS320E17	200	256		4K	4K	6×16	2		1	DIP/CERQUAD/PLCC
	TMS320C16	114	256	8K		64K	8×16				QFP
	* TMS32020	200	544			128K	16×16	1	•	1	PGA
	* TMS320C25	100	544	4K		128K	16×16	1	•	1	PGA/PLCC
	TMS320C25-33	120	544	4K		128K	16×16	1	•	1	PLCC
	* TMS320C25-50	80	544	4K		128K	16×16	1	•	1	PGA/PLCC
	* TMS320E25	100	544		4K	128K	16×16	1	•	1	CERQUAD
	TMS320C26	100	1.5K	256		128K	16×16	1	•	1	PLCC
	* TMS320C50	50	10K	2K		192K	64K×16	2	•	1	QFP
	* TMS320C51	50	2K	8K		192K	64K×16	2	•	1	QFP
	TMS320C51-57	35	2K	8K		192K	64K×16	2	•	1	QFP
Floating-Point	* TMS320C30	60	2K	4K		16M	16M×32	2	••	2	PGA
	TMS320C30-27	74	2K	4K		16M	16M×32	2	••	2	PGA
	TMS320C31	60	2K			16M	16M×32	1	••	1	QFP
	TMS320C31-27	74	2K			16M	16M×32	1	••	1	QFP

* For information on military versions of these devices, contact your local TI sales office. • External DMA •• External/Internal DMA

parallelism. The TMS320 instruction set contains DSP-specific commands that perform several operations in the same machine cycle, such as single-cycle multiply/accumulate/data move. Large on-chip memories and peripherals increase performance, reduce system size and cost and limit power consumption.

The TMS320 DSP family is currently made up of five generations of DSPs and a variety of price/performance alternatives. The TMS320C1x, TMS320C2x and TMS320C5x generations are comprised of fixed-point DSPs, while the TMS320C3x and TMS320C4x are floating-point generations. Spin-offs based on the core CPU of each generation offer new memory and peripheral configurations to address specific applications needs. New higher-performance, code-compatible generations are developed to provide an easy product upgrade path while preserving the user's software investment.

TI's commitment to providing a complete DSP solution, high-performance and cost-effective devices, world-class development support and a broad choice of DSPs has made the TMS320 the DSP of choice.



The TMS320 fixed-point DSP cost per MIP and floating-point cost per MFLOP continue to decrease over time.

MORE TMS320 INFORMATION

Move your application into the mainstream with the leader in DSP. Complete and return the attached coupon for TMS320 DSP technical product information. For pricing and availability information, contact your local TI Field Sales Office or authorized distributor.

TI Worldwide Sales Offices

ALABAMA: Huntsville: 500 Wynn Drive, Suite 514, Huntsville, AL 35805, (205) 837-7530.

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COLORADO: Aurora: 1400 S. Potomac Ave., Suite 101, Aurora, CO 80012, (303) 368-8000.

CONNECTICUT: Wallingford: 9 Barnes Industrial Park Rd., Barnes Industrial Park, Wallingford, CT 06492, (203) 269-0074.

FLORIDA: Altamonte Springs: 370 S. North Lake Blvd, Altamonte Springs, FL 32701, (305) 260-2116; **Ft. Lauderdale:** 2950 N.W. 62nd St., Ft. Lauderdale, FL 33309, (305) 973-8502; **Tampa:** 4803 George Rd., Suite 390, Tampa, FL 33634, (813) 885-7411.

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MICHIGAN: Farmington Hills: 33737 W. 12 Mile Rd., Farmington Hills, MI 48018, (313) 553-1569. **Grand Rapids:** 3075 Orchard Vista Dr. S.E., Grand Rapids, MI 49506, (616) 957-4200.

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